

Wisconsin AV Proving Grounds

Proposal for DOT-OST-2016-0233, US Department of Transportation
Designation of Automated Vehicle Proving Grounds Pilot

December 2016

Submitted by the University of Wisconsin-Madison and MGA Research Corporation, in collaboration with the City of Madison and the Wisconsin Department of Transportation

1. INTRODUCTION

Avid attention on autonomous or automated vehicle (AV) technology is widespread and burgeoning, and the collaborative groundwork being laid in Wisconsin is a prime example. Wisconsin seeks to lead the nation in developing an understanding of this transformative technology and how it can be harnessed for the greater good of society. Researchers with the College of Engineering at the University of Wisconsin-Madison (UW-Madison) have been contributing to the literature on the benefits and technical aspects of AV, as well as working on policy issues with state entities. AVs are rapidly pushing technical, safety, acceptability, legal, regulatory, and liability boundaries.

AVs have significant potential to improve safety and quality of life. More specifically, AV transit can provide *ladders of opportunity* to all, including previously underserved communities. Furthermore, AVs can bring significant new research and development opportunities to UW-Madison and new businesses to the state of Wisconsin, including startups and tech companies.

AV systems will evolve through the Society of Automotive Engineers (SAE) levels of automation¹ over the next few decades, eventually replacing the majority of the personal and commercial fleet. To get to this point, our team realizes that multiple facilities will need to be used for different stages of testing and development. This proposal seeks designation of the Wisconsin AV Proving Grounds, consisting of multiple sites.

With a designated proving ground in Wisconsin, vehicle testing can be done to develop and share best practices to address safety concerns, including under adverse conditions such as Upper Midwest winter weather.



Initial testing can take place in a closed environment with both the MGA Research Corporation² site in Burlington, WI and the Road America race track in Elkhart Lake, WI. Next, the collaboration between UW-Madison, Epic Healthcare Systems, and the City of Madison to operate AVs on limited-use campus facilities will be used for practical testing in a controlled environment. Select facilities in the City of Madison as well as WisDOT state highways (as part of the W-Highway³ program) will be available for final stages of development and deployment. A more detailed overview of facilities is included in Section 3.

A great deal of momentum in Wisconsin began one year ago upon the USDOT announcement of the Smart City Challenge opportunity. Madison was among the smallest population applicants, but the UW-Madison and City of Madison team had top level support and numerous partners

¹ Six levels, from 0 (no automation) to 5 (full automation)

² So named in 1977 for its founders Miller, Greene, and Arendt

³ W-Highway is the emerging state test bed for connected vehicle research

engaged in a proposal that emphasized improving urban mobility and equity through smart AV microtransit. Automated microtransit or minibus vehicles such as those provided by EasyMile, Local Motors, Navya, and others are beginning to take off, as we have seen at the recent ITS World Congress and will see again at the Consumer Electronics Show in early January. Yet, as technology and user acceptance evolves, there is a large unmet need for proving grounds for this type of service as well as for broader AV technologies.



2. OBJECTIVES AND APPROACH

2.1. Targeted Contributions

The mission of the Wisconsin AV Proving Grounds is to safely and rapidly advance AV development and deployment by providing a full suite of test environments coupled with research and open data. Our team's philosophy holds paramount safety, followed by best practice tenants of security and open data. Without these fundamental elements, we recognize it makes little difference what our readiness is or what research and development objectives may be.

Efforts here build in part upon concepts and partnerships in Madison's Smart City initiatives. These involve practical testing, deployment, research, and data collection to demonstrate best practices in automated mobility. Focus will be placed on disseminating results – open data, standards applicability, software development, cybersecurity lessons learned, etc. – to encourage further deployments elsewhere. The advances accomplished with the Proving Grounds will influence policies for AV deployments nationally and will lead to increased city- and state-wide deployments.

Research areas to be emphasized include some elements that overlap with the National Highway

Traffic Safety Administration's 15-point Safety Assessment.⁴ These elements and others include the following:

- Data and sensing including LIDAR, GPS, cameras, communications, and other sensors. This parallels the Safety Assessment point on Object and Event Detection and Response.
- Testing and validation methods for AV systems.
- Vehicle operations including speed, acceleration/deceleration, performance on grades and curves, and in the case of electric vehicles, range and charging time.
- Inclement weather operations including snow, ice, fog, and high winds. One of the larger unknowns for AVs is winter operation.
- Interaction with pedestrians, bicycles, mopeds, cars, and traffic control devices.
- Human-machine interfaces such as sensors, communications, and responses. For this item, our team has the opportunity to leverage the full-scale driving simulator at UW-Madison's College of Engineering.
- Passenger comfort, public perception, and safety improvement.
- AV microtransit developments, enhancements, and testing:
 - Display live vehicle location on map shown at stops and accessible on connected devices.
 - Outfit vehicles with wireless internet connectivity and emergency telephones.
 - Outfit vehicles and route infrastructure with vehicle-to-infrastructure (V2I) equipment.
 - In the near term, vehicles include an operator at all times for emergency and legal considerations, as well as for public relations and outreach.
 - Vehicles limited to 25 mph operation to classify as a low-speed vehicle (LSV) per NHTSA and WisDOT.

⁴ <https://www.transportation.gov/AV>

The Wisconsin AV Proving Grounds offers a progression of facility types, which is essential for safe testing and deployment, and allows robust evaluation across a range of Operational Design Domains (ODD). Some facilities have already been testing AV technologies, and all of the facilities stand ready to test AVs as part of the Proving Grounds team. The MGA facility in particular is readily willing to modify route features, create specific testing events, or add equipment.

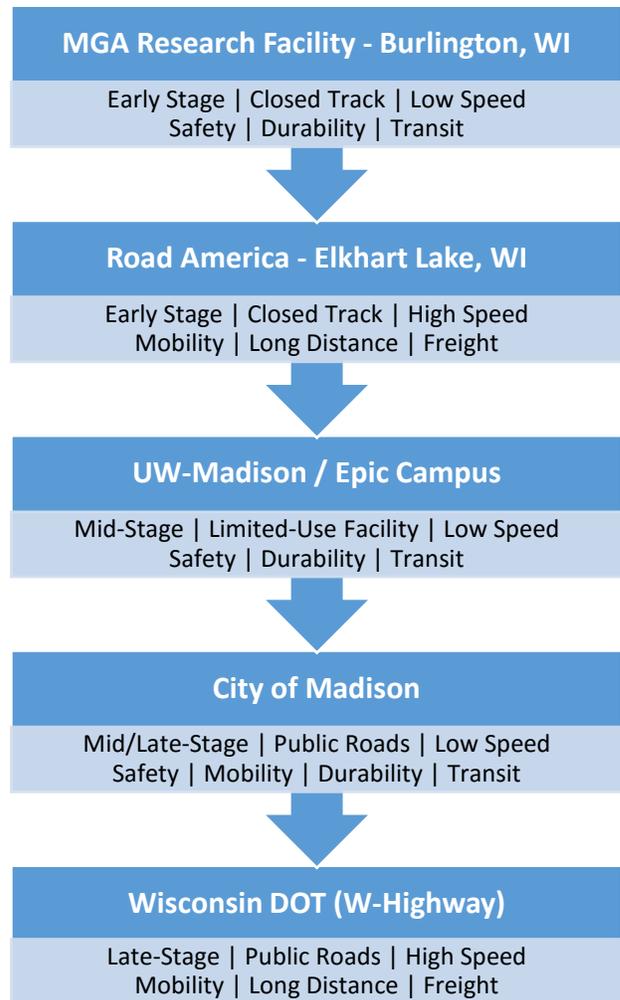
We see two simultaneous trajectories of AV development. One entails additional features in consumer vehicles available already, e.g., Tesla. This represents vehicles that may be driven anywhere – any ODD – with autonomy continuing to progress through the SAE levels. A second trajectory are those striving to be fully autonomous, e.g., Google or Navya, and the progression here is not through the SAE levels but through ODDs. This later case may be referred to as the “Transit Leap” or gradual spatial expansions over the next 35 years.⁵

- Leap 1: driverless short trips in local fixed loops (now)
- Leap 2: first/last-mile service in small areas (2020)
- Leap 3: larger-area (CBD, island) service to most addresses (2030)
- Leap 4: city-wide service, any address, any trip (2040)
- Leap 5: megaregion, any time anywhere, any distance (2050)

The Wisconsin AV Proving Grounds team understands as deployment for AVs progresses in this fashion, closed-course testing can be done to address elements of all leaps. Limited-use facilities and public roads will likely begin deployment in the order listed.

The following diagram shows the general flow of the proving grounds. Although testing can occur fluidly at any point in the process, the main idea is that the closed courses including MGA and Road America would be used for early stage tests

whereas the public roads in the City of Madison and WisDOT highways would be used for later stage testing after much initial vetting at the closed facilities.



2.2. Proving Grounds Team

The team includes the second largest city in Wisconsin, the region’s largest private employer, a premier private proving grounds in operation for decades, one of the nation’s most reputable race tracks, public agencies, and Wisconsin’s flagship research university. Researchers with the UW-Madison College of Engineering will manage and oversee all aspects of the AV proving grounds work, as well as provide research, development,

⁵ “Transit Leap” credit to Bern Grush and John Niles, <http://endofdriving.org/>

and data stewardship. The main partner in this team is the physical proving grounds facility owned and operated by MGA Research Corporation near Burlington, WI. Both the City of Madison and the Wisconsin DOT are public agency partners for AV policy development, regulation, and operations on their roads. In addition, the founder and team leader of Team Mojavatton – Colorado's entry in the 2005 DARPA Grand Challenge and the 2007 Urban Challenge – now lives in Madison and collaborates with our AV Proving Grounds team.

participate in the quarterly safety officer meetings, and coordinate with safety liaisons at each test facility.

Communications Officer

The communications officer's primary objective will be to ensure lines of communication remain open and committed to contributing to the Community of Practice. This includes internal communication between members of the Wisconsin AV Proving Grounds team as well as external groups including other proving grounds and the USDOT. This person will participate in meetings and conferences relevant to the Community of Practice and will complete all activity reports.

Proving Grounds Coordinator

The proving grounds coordinator will ensure that work is being completed in an efficient manner and information is being shared appropriately for all AV testing. This includes making sure data is being shared internally and openly, preparing and disseminating performance metrics and results documentation, coordinating research efforts, coordinating testing efforts, and engaging stakeholders.

UW-Madison has AV-related research and development underway across a variety of units and disciplines. This allows the team to draw on whatever is needed as different testing and deployment opportunities arise in the years to come.

- Department of Civil and Environmental Engineering
 - AV Research and testing
 - Wisconsin TOPS Lab
 - Data hub
 - WisTransPortal transportation data hub (described later)
 - All data will be housed within the college and shared openly via the ITS Research Data Exchange (RDE)
- Department of Industrial and System Engineering
 - Human factors / optimization and the full-scale driving simulator
- Department of Geography
 - High-resolution 3-D mapping



2.2.1. UW-Madison

UW-Madison will be the lead for the Wisconsin AV Proving Grounds team with the College of Engineering being the hub of activity. Three members of the Traffic Operations and Safety (TOPS) Lab will be appointed to roles to ensure communication and collaboration with other AV proving grounds and the USDOT.

Safety Officer

The safety officer will be a member of the safety group of the Traffic Operations and Safety (TOPS) Lab within the Department of Civil and Environmental Engineering. This person will develop the team's safety management plan,

- Department of Computer Science
 - Network and data science, WiRover mobile vehicle communications
- Department of Electrical and Computer Engineering
 - Telecommunication and hardware design
- Department of Mechanical Engineering
 - Automotive / Vehicle / Engine / Power
- MetroLab Network
 - The national network of City-University collaboration

2.2.2. MGA Research Corporation

MGA Research Corporation is an international provider of services and equipment to the automotive, aerospace, and energy storage industries. Within the automotive industry, MGA is well recognized in vehicle crashworthiness and interior components such as seats, instrument panels, and restraint systems.

MGA is independent and privately held, headquartered in Akron, NY. The Burlington, WI facility was purchased from Chrysler Corporation in October 1988. The facility was the American Motors Corporation (AMC) Proving Grounds that Chrysler closed after purchasing AMC. MGA has extended the vehicle crash testing capabilities of the facility with the additions of multiple specialized facilities to address front, side, rear, and rollover crash modes, and real world accident scenarios. In addition to Akron, NY and Burlington, WI, MGA has facilities in:

- Troy, MI – Detroit area
- Mississauga, Ontario, Canada
- Greer, SC
- Lincoln, AL
- Irving, TX
- Manassas, VA – Washington DC region
- Shanghai, China

2.2.3. Road America

Road America is a 640-acre motorsports facility established in 1955. The four-mile road circuit offers high-speed straights, challenging turns, and dramatic elevation changes. The Blain's Farm &

Fleet Motorplex is a short combination paved and dirt track used for karting, supermoto, and autocross activities.

The track hosts major motorcycle and auto racing series on public race weekends, including AMA, NASCAR, the American Le Mans Series, and IndyCar. The facility is committed to safety as their number one goal. Their safety director is fully trained with over 30 years of motorsports safety experience in various environments including clay ovals, drag racing, road courses, and paved ovals. This individual is a past member of the CART safety team and is currently the Secretary of the NFPA 610 Safety in Motorsports Committee.



2.2.4. City of Madison

The City of Madison is committed to supporting AV research and practice. As stated in the Smart City Challenge proposal, “Madison will become a **living mobility lab** that will evolve, test, and implement smart transportation solutions to move people, goods, and services around Madison more equitably, safely, and efficiently.” Madison is strongly motivated by the improvements to mobility and equity for underserved populations that automated microtransit will bring.

The City of Madison, with UW-Madison, is a founding member and an active participant in the MetroLab Network, a 2015 White House initiative which calls upon universities and cities to collaborate in using technology to solve urban challenges. And just this October 2016, Madison was one of 16 cities selected to form the Transportation for America (T4A) Smart Cities

Collaborative, with support from Alphabet's Sidewalk Labs. Madison is focusing on pursuing automated vehicles, one of three of the T4A Collaborative's core areas.

2.2.6. Wisconsin DOT

WisDOT is the lead statewide agency for automated vehicle policy and testing guidance. Somewhat unique to Wisconsin, both the Wisconsin State Patrol (WSP) and the Division of Motor Vehicles (DMV) are included *within* the Department of Transportation. Having these under one agency is a significant advantage for AV policy development.

WisDOT will support disseminating results of the AV proving grounds research through a statewide program to engage stakeholders. This will include outreach material to explain why this research is so critical to the Wisconsin public and why Wisconsin is involved in testing AVs.

2.2.7. Other Private Entities

First among other private partners is Epic Healthcare Systems. As an existing partner with Madison's Smart City efforts, a major supporter of innovative technology, and with a private corporate campus available for AV microtransit deployment, they are a natural fit for the Wisconsin AV Proving Grounds.

The Wisconsin AV Proving Grounds is neither affiliated with nor supported by any specific AV or AV-related manufacturer. Although we have existing relationships with some private entities, we welcome all providers to utilize the proving grounds. Some potential examples include:

- Microtransit: Navya, EasyMile
- Sensor manufacturers: ZF TRW, Delphi, Lynx
- Automakers: Ford, GM, Tesla
- AV-engaged companies: Google, Uber
- Freight: Schneider National (based in Wisconsin)
- Agriculture and implements of husbandry (IoH): Case IH, John Deere
- Military: Oshkosh Defense (based in Wisconsin)

2.3. Demonstrated Investments

The members of the AV Proving Grounds team have demonstrated commitment to the testing of AVs and will continue to invest as clients and testing procedures are developed. The following are a list of developments either completed or in process to support the AV Proving Grounds:

- Existing collaboration on smart cities, research and publishing, legal and liability issues, etc.
- The MGA facility and Road America are private, restricted-access facilities, and are already approved for automotive testing.
- MGA has worked and continues to work with sensor suppliers on testing.
- WisDOT, UW-Madison, and the City of Madison have appropriated funds to deploy connected vehicle hardware on W-Highway facilities as part of the AASHTO SPaT Challenge. This will allow for communication with connected vehicles and AV systems.
- The College of Engineering has developed resources that will support AV data collection, including WisTransPortal.



2.4. Readiness

The Wisconsin AV Proving Grounds team is ready to start right away. The following items address the team's readiness for AV testing:

- Test tracks at MGA and Road America are ready for testing immediately.
- MGA supports testing by multiple users at one time.
- All data collected on official proving grounds projects will be shared openly on WisTransPortal (which is publicly available), unless specific confidentiality agreements stipulate otherwise.
- MGA is committed to adaptable infrastructure to meet client and testing needs.

- Each facility that is part of the proving grounds will have a designated point of contact, shown in Section 4. These members will be collaborating with each other through the team’s Proving Grounds Coordinator.
- The City of Madison has been preparing for AV testing on public roads for the last year since the Smart City Challenge. The city continues to engage the community and address concerns for usage of public roads in AV tests.

In the near term, the development of policy in Wisconsin and advancement of legislation will focus on housekeeping items, for instance, enabling connected/automated truck platooning as an exception to the current statute regarding minimum following distance, and clarifying the distinction in statute whether a driver is a human or an autonomous system. In the longer term, policy and regulation will follow NHTSA’s model policy and best practices from other states to avoid contributing to the patchwork of laws of concern to automakers.

2.5. Safety Management Plan

A safety management plan will be developed to ensure that all testing completed at any proving ground sites is done in a safe and well-documented manner. This plan will outline safety plans for all personnel involved in testing, safety protocols for testing on all open roads (including limited-use facilities and public roads), safety checks for all automated devices used at the proving grounds, and plans for fallback, contingency, and emergency response. Furthermore, each facility also maintains their own safety documents and procedures.

2.6. Adherence to Laws, Regulations, and Federal Policy

From a statewide legal standpoint, Wisconsin is one of several states that does not explicitly prohibit AV operation, and the Wisconsin Assembly has AV on their legislative agenda for the current term⁶ to further improve and clarify statute regarding AV.

Regarding legal and liability concerns with AV on public routes, exploration of these to ensure adherence to laws and regulations has been done as a collaboration among Madison City Attorney’s Office, the UW-Madison Office of Legal Affairs, and the Wisconsin DOT Office of General Counsel, with consultation from the State Attorney General’s Office.

⁶ <http://legis.wisconsin.gov/eupdates/asm63/ForwardAgenda2016.pdf>

3. FACILITIES

3.1. MGA Burlington

The MGA Proving Grounds occupies approximately 400 acres and has over 20 miles (32 kilometers) of paved and unpaved roadway divided among multiple tracks. Its location near Burlington in Southeast Wisconsin is ideal for AV testing. Being just 50 minutes from the Milwaukee Mitchell airport, and 90 minutes from Chicago's O'Hare airport, access is convenient from anywhere in the world. Being a secured site in a rural setting means it affords greater security and confidentiality than many other proving grounds.

- MGA's Upper Track is a low-frequency, high amplitude type of design that is made up of four surfaces: Ripple Lane, Pothole Lane, Cobblestone Lane and Body Twist Lane.
- MGA's Main Track is a 1.2 mile (1.9 km) two lane oval designed for 55 mph (88 kph) speed.
- MGA's Inner Track consists of two loops, the Driveline loop and the Chassis loop.
 - The Driveline loop comprise a smooth surface road that provides short radius 180° turns, various elevations, and grades ranging from 15% to 28%.
 - The Chassis loop is designed to provide high frequency/low amplitude vehicle inputs and consists of surfaces such as alternate rolls, spot patches, washboards, shimmy exciter, and chatterstrips.
- The 1.6 miles (2.6 km) of the Inner Track is almost equally divided between these two loops.
- MGA's North Track is a 5.3 mile (8.5 km) course with body rolls, chatterstrips, and railroad crossings. The area around this track also includes a brake water soaking pit.

- MGA's Truck Track is the name given to a 1.5 mile (2.4 km) gravel road course since it was originally designed for truck chassis testing. Included in this course/area is a saltwater soaking pit, 30% grade, and Figure 8 track.

MGA also has designed a cross country/off road course that is used for durability and shakedown tests of four-wheel drive vehicles. The cross country course utilizes such objects as inclines, ditches, fallen trees, field stone, and swamps. Depending on the types of vehicles and tests, MGA can modify the cross country course to meet specific needs.

Below is an aerial view of the MGA facility in Burlington. The main areas planned for testing of AVs are the main track oval and the inner track, both seen on the left of the image below.



The MGA facility has strict safety guidelines in place that will be modified to keep AV tests on the facility safe. Specific guidelines that currently are in place include usage of the test tracks, usage of access roads, distracted driving, motorcycles, seat

belts, and general conduct. MGA has a long history working with NHTSA.

The facility is currently ready to use. The section of track designated for AV testing is currently underutilized and ready for scheduling during all seasons. The track is operational with many safety features already constructed, however additional equipment installation and modifications can be completed as needed to support the AV test being conducted.

3.2. College of Engineering

The UW-Madison College of Engineering will provide the home for research and data services. The focal point is the TOPS Lab, which includes the WisTransPortal, and a diverse team of researchers across multiple departments has world-class IT resources at their disposal.

The WisTransPortal system provides a central source of traffic operations, safety, and intelligent transportation systems (ITS) data, with specific capabilities for data archiving, real-time services, and server applications development. The WisTransPortal supports day-to-day operational requirements with connections to several major systems including Wisconsin 511 and the WisDOT Statewide Traffic Operations Center (STOC) Advanced Traffic Management System (ATMS). It is also used throughout Wisconsin and regionally by all levels of state and local government, law enforcement, universities, engineering firms, and others for a variety of traffic management, maintenance, planning, and research purposes.

The WisTransPortal is also essential for transportation engineering research in providing a robust 'big data' warehouse of traffic operations and safety information. The TOPS Lab manages a wide range of archived traffic operations and safety data in the WisTransPortal for research and performance purposes, and the WisTransPortal provides several real-time data feeds to support center-to-center data sharing, traffic incident management, and traveler information.⁷

⁷ Learn more about the WisTransPortal at <http://transportal.cee.wisc.edu/about/>

3.3. Campus AV Routes

Initial AV microtransit vehicles deployed on the UW-Madison campus will lay the foundation for future expansion. Targeted routes and applications include the following:

- First-mile/last-mile connectivity for residents of the campus housing community at Eagle Heights during non-peak hours where other service is limited (shown below).
- Replace a conventional diesel shuttle route to UW-Hospital.
- Additional research and development purposes on multiple routes.

Though primarily on campus roads exclusively, these routes are done in coordination with the City of Madison for those portions crossing city roads.



3.4. Additional Partner Facilities for Expanded Deployment

3.4.1. Road America

The facility includes the following features which are available for scheduling as part of the proving grounds:

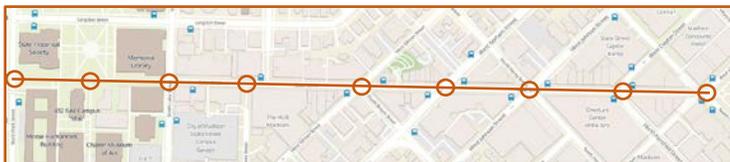
- Four-mile road circuit for high-speed vehicle testing
- One-mile go-kart track (can be used for autocross or similar with full size vehicles)
- 14 miles of paved access roads
- Off-road course
- Several large paved paddock areas
- Skid Pad
- High availability during the winter
- Availability for night testing

3.4.2. Epic Healthcare Systems Campus

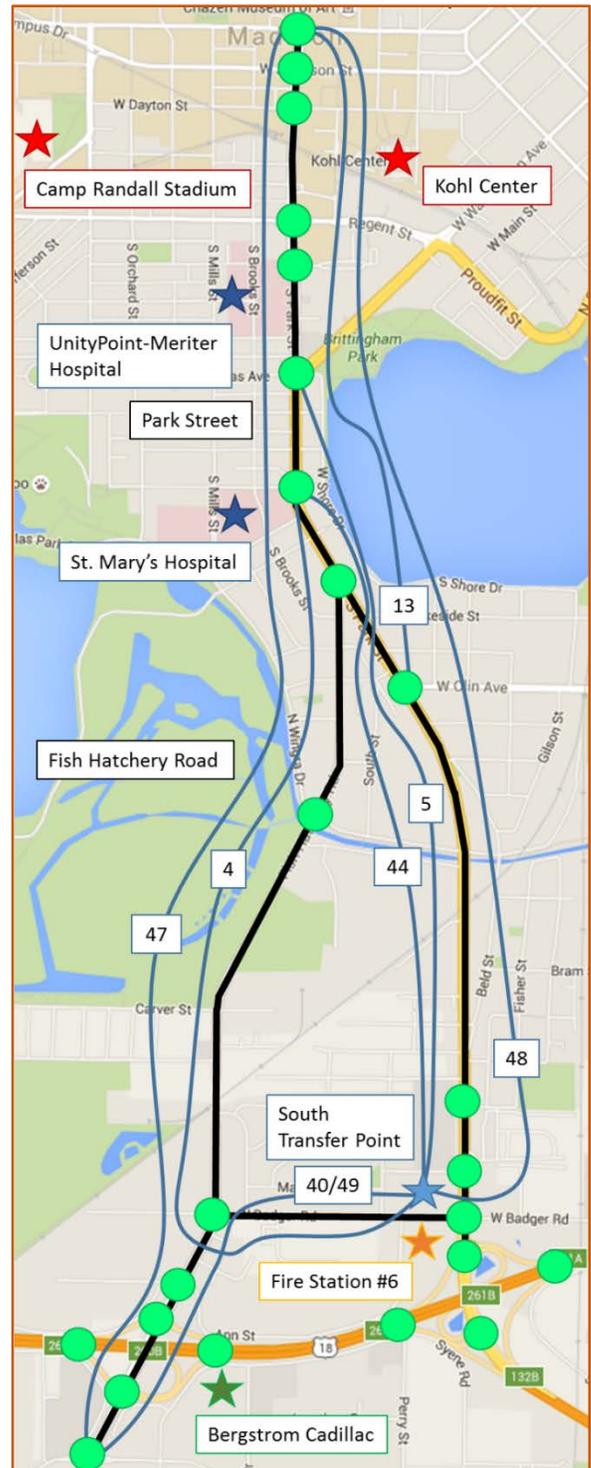
AV microtransit vehicles deployed at Epic’s private corporate campus for employee/visitor passenger service will replace existing conventional fuel shuttles. This deployment solves Epic’s campus mobility problem while establishing an exemplar for corporate campuses across the country.

3.4.3. City of Madison

State Street is a restricted-use roadway connecting the Capitol Square to the UW campus. This route boosts public awareness and allows for on-road testing in a controlled space. This route is shown below.



Other routes in the central business district are also suitable, which offer testing grounds for various modes of transportation. The Park Street Corridor is currently being developed for connected vehicle testing, but would also be a good site for AV tests. The current project plan is shown below.



3.4.4. State Roads and W-Highway

The least restrictive ODD involves a complete network with a variety of traffic control, geometries, traffic conditions, interactions with other road users, weather, lighting, terrain, and pavement condition. This includes state roads, and the W-Highway corridor will be the ideal place to start for monitoring and feedback.

W-HIGHWAY

4. Partners and Primary Points of Contact

Partner	Name, Title	Contact Info
UW-Madison	Peter Rafferty TSM&O Program Manager	608-516-9382 prafferty@wisc.edu
MGA Research Corp	David Winkelbauer Director of Operations	262-763-2705 david.winkelbauer@mgaresearch.com
City of Madison	Yang Tao Assistant City Traffic Engineer	608-266-4815 ytao@cityofmadison.com
Wisconsin DOT	Anne Reshadi Traffic Systems & Management Section Chief	414-227-2149 anne.reshadi@dot.wi.gov
Road America	Mike Kertscher Director of Business Development	920-892-4576 mkertscher@roadamerica.com
Epic	Pete Scharenbroch BIM Manager	608-777-0126 pete.scharenbroch@jpcullen.com
